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Research Article

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Assessment of Physicochemical Parameters and Heavy Metal Levels in Surface Water and Sediment of Mgbuodohia River, Port Harcourt, Nigeria

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Abstract

The assessment of water quality is indispensable for suitability of human consumption. In this study, water and sediment samples were collected from two sampling stations along Mgbuodohia River for a period of three months and analysed for physicochemical and heavy metal parameters using standard method of analysis [1]. The results showed no significant difference between stations I and 2 ($p > 0.05$) for all measured parameters. The different measurements for surface water are as follows: Temperature 28.3±0.70 °C, pH 7.0±0.19, Conductivity 14122 ± 4280 µS/cm, Salinity 7.77 ± 2.56 ppt, TDS 12793 ± 4069 mg/l, Turbidity 3.09 ± 0.65 NTU, Alkalinity 39 ± 9.61 mg $CaCO_3$/l, Total hardness 5024 ± 1543 mg $CaCO_3$/l, Calcium 499 ± 166 mg/l, Magnesium 921 ± 290 mg/l, Chloride 12623 ± 5581 mg/l, DO 6.93 ± 2.87 mg/l, BOD 1.85 ± 0.63 mg/l, Nitrate 0.48 ± 0.20 mg/l, Phosphate 0.69 ± 0.02 mg/l, and Sulphate 630 ± 197 mg/l. Heavy metals had their respective levels for station 1(downstream) and station 2 (upstream) as 0.7 ± 0.51 mg/l and 0.34 ± 0.19 mg/l for Pb, 0.20 ± 0.10 mg/l and 0.21 ± 0.02 for Cd, 2.10 ± 0.10 mg/l and 1.61 ± 1.69 mg/l for Fe while Zn was not detected. The water Quality Index, WQI = 425. The sediment metal concentrations for stations 1 and 2 are 0.38 ± 0.50 mg/kg and 0.15 ± 0.18mg/kg for Pb, 0.10 ± 0.00 mg/kg and 0.03±0.04 mg/kg for Cd, 18.02 ± 11.34mg/kg and 28.68 ± 5.10mg/kg for Fe and 0.13 ± 0.12 mg/kg and 0.34 ± 0.15mg/kg for Zn respectively. The levels of sulphate, phosphate and chloride were above the recommended standard. The mineralization of the river was high due to the dissolved ions that were very much above the permissible limit. All the metals were within the recommended standard in water and sediment except Fe. The WQI indicated that the overall quality of the river was bad and not suitable for human use as drinking water.

Keyword: Physicochemical Parameters; Heavy Metal; Water Quality Index (WQI)

Introduction

Water is pertinent and indispensable natural resource that sustains all living things [2]. It may be classified into surface and ground water. Both ground and surface water can be extracted for agriculture, industrial and municipal uses. About 71% of the earth surface is covered by water of which ocean holds about 96.5% of all earth's water which is saline. Surface water includes river, lake, ocean, etc. The fresh water sources such as water falling from the skies and moving into streams, rivers, lakes and ground water provide people with water needed for day to day activity. Despite the abundance of water, availability and affordability of portable water is a challenge to most communities of the developing nations of the world as greater part of the available water are marine or brackish in nature [3]. This valued resource is increasingly being threatened by the anthropogenic activities as the human population grows exponentially and demand more quality water for domestic and commercial purposes [4]. The quality of both surface and ground water is a function of either natural influences or human activities [5]. On a general note, the anthropogenic outputs constitute a constant source of pollution whereas runoff is a seasonal phenomenon operating under the influence of climate [6, 7].

Rivers are the most important freshwater resource for man. Unfortunately, river water is constantly being polluted by indiscriminate disposal of sewage, industrial waste and plethora of human activities, which adversely affects their physicochemical properties including microbiological quality content. It is a serious growing problem. The increasing amount of industrial and municipal waste that are being discharged into rivers has led to various deteriorating effects on aquatic organism which accumulate pollutants directly from contaminated water and indirectly via food chain. Human feed on these aquatic animals hence the accumulated pollutants are transferred into the body system causing diseases and infections [2].

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Water quantity is neither a static condition of a system, nor can it be determined by the measurement of only one parameter. Rather, there is a range of physical, chemical and biological components that affect water quantity. These variables provide a general indication of water pollution, whereas some enable a direct or indirect tracking of pollution sources [4].

Among all the environmental pollutants, heavy metals are of particular concern due to their toxicity, wide source, non-biodegradable features and their ability to accumulate over a long period of time [8]. They are capable of causing harmful effects on both marine organisms and humans. These metals are rapidly and efficiently associated with the sediment through adsorption onto surface particles, hydrolysis and co-precipitation [9].

Heavy metals are metals of relatively high densities with great adverse effect at low concentration. They are usually mobile in the environment and are bioaccumulated in the food chain, thereby posing a threat to public life. It affects human physiology when found above permissible limit [10].

Since changes in the quality of river caused by effluents from industries, sewage, municipal wastes and nutrients from a plethora of human activities may have impacted negatively on Mgbuodohia River and have detrimental effect on the aquatic flora and fauna as well as beneficiaries of the river water [11, 12]. Thus, to assess the water quality, some physicochemical parameters and heavy metal levels are determined in surface water and sediment, which may be subjected to some statistical analysis. In this study, t-test, and Water Quality Index (WQI) are employed.

Study Area

The study was carried out on the Mgbuodohia river segment of the Island River extending to Mgbochimini the host community of Agip Oil Company. It is a mangrove intertidal wetland with increasing and decreasing tides depending on the lunar cycle [13]. At high tide salinity increases and decreases at low tide. The river serves as receiver of effluents from neighbouring oil and gas, construction and mining companies. Apart from the industrial activities being carried out in the area, the river is a constant source of sea food.

The sampling stations were georeferenced through Global Positioning System (GPS). These were the downstream and upstream named Station 1 and station 2 respectively. Station 2 is located at the river bank of Mgbuodohia community having a dump site just by the side of the river (06º 97’ 27.0” E; 04º 79’ 21.1” N). Station 1 is located close to Yeeche sand dredging company (06º 97’ 64.3” E; 04º 79’ 85.8” N).

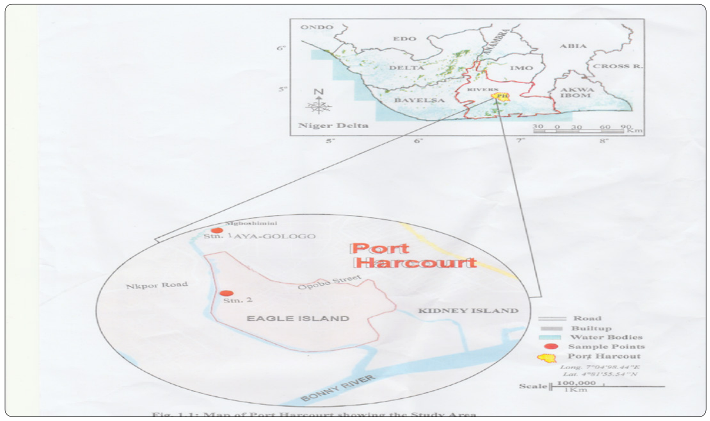

Figure 1: Map of the Study Area

Methodology

Sample Collection

Samples (water and sediment) were collected for a period of three months (December 2017 – February 2018) from two (2) sampling stations (the up and downstream).

Surface Water

Water samples were collected at the two stations using one litre plastic bottles dipped into the river to take the sub-surface water after rinsing bottles with the water first. The water was allowed to flow freely into the bottle after which it was withdrawn when full. Water for heavy metal was collected with 100ml sterile bottle of which five (5) drops of nitric acid was added to prevent the oxidation of the metals. Water samples for dissolved oxygen and biochemical oxygen demand were collected in 2 separate 75ml amber bottles. The DO samples were fixed immediately after collection by adding 5 drops each of winkler I and II reagents while the BOD samples were stored alongside the DO samples after collection before they were taken to the laboratory. All analysis was done using standard methods.

Sediment

The river bed sediment samples were taken at a depth of 0 – 5cm by scooping with plastic hand towel which were immediately placed in a foil and transferred into a well labelled polythene bag. It was taken to the laboratory where it was air dried at room temperature, prior to analysis.

Analytical Methods: The different parameters and standard methods of analysis used are presented in Table 1.

Table 1: Water quality parameters and analytical methods

Parameter	Analytical Techniques
Temperature Salinity ElectricalConductivity Resitivity pH Total dissolved solids	Handheld multiparameter (ExTECH DO700)
Nitrate	Colorimetry
Phosphate Sulphate Total hydrocarbon	UV Spectrophotometer
Chloride Total Hardness Total Alkalinity Dissolved oxygen	Titration
Biochemical oxygen demand	5-day incubation at 20°C
Iron Chromium Cadmium Manganese Lead Nickel Zinc Copper	Instrumental, AAS(200 Model)

Statistical Analysis

All of the statistical analyses were conducted using SPSS, version 20.0 and Excel

Water Quality Index (WQI) is a method used to determine how polluted a water body is using 9-12 environmental parameters and a weighing factor to differentiate between important parameters and the less important ones. Q-Values are numbers that are given in a table and correlate to the level of each parameters to characterise each on a scale of 0-100 [14]. Weighted Arithmetic Water Quality Index method was used. This method classified the water quality according to the degree of purity by using the most commonly measured water quality variables [15, 16]. The calculation was made by using the following equation:

$$WQI = \frac{\sum QiWi}{\sum Wi} \quad (1)$$

The quality rating scale (Qi) for each parameter is calculated by using this expression

$Qi = \quad 100[(V_i - V_0/S_i - V_o)]$

Where

V_i = is the estimated concentration of ith parameter in the analysed water

V_0 = is the ideal value of the parameter in the pure water

V_0 = 0 (except pH = 7.0 and DO = 14.6 mg/l)

S_i = is the recommended standard value of ith parameter

The unit weight (W_i) for each water quality parameter is calculated by using the following formula:

$$W_i = \frac{K}{Si}$$

Where

K = Proportionality constant

K can be calculated by using the following equation;

$$K = \frac{1}{\sum(1/Si)}$$

Results and Discussion

The table (2) below shows the results of the descriptive statistics of physicochemical parameters and their corresponding mean, standard deviation and range. Station 1 is the downstream while station 2 is the upstream.

Table 2: The Mean Concentration of Physicochemical Parameters in the Surface Water

S/N	Parameter	Station 1	Station 2	Range	Mean of 2 Stations	WHO	NESREA
1.	Temperature (°C)	28.40 ± 0.74	28.20 ± 0.80	27.40 – 29.00	28.30 ± 0.70	0 – 30	<40
2.	pH	7.10 ± 0.05	6.90 ± 0.30	6.60 – 7.1	7.00 ± 0.19	6.5 – 8.5	6.2 – 9.2
3.	Conductivity (µS/cm)	16753±4295	11490±2566	8890 – 21400	14122± 4280	1200	500
4.	Salinity (ppt)	9.30 ± 2.64	6.19 ± 1.36	4.66 – 12.20	7.77 ± 2.56	0.04	-
5.	TDS (mg/l)	15333±4050	10253±2290	7660 - 19800	12793± 4069	1000	2000
6.	Turbidity (NTU)	3.20 ± 0.94	2.97 ± 0.34	2.55 – 4.29	3.09 ± 0.65	5	5
7.	Alkalinity (mg $CaCO_3$/l	45.30 ± 6.40	36.70 ± 6.11	26 – 50	39.00 ± 9.61	150	-
8.	Total Hardness (mg $CaCO_3$/l	6208±617	3840±1167	2496 – 5952	5024± 1543	150	-
9.	Calcium (mg/l)	614 ± 154	384 ± 77	307 – 768	499 ± 166	75	-
10.	Magnesium (mg/l)	1140 ± 71	703 ± 248	422 – 1218	921 ± 290	30	-
11.	Chloride (mg/l)	15180±5801	10065±4958	4950 – 21780	12623± 5581	250	-
12.	DO (mg/l)	5.00 ± 0.81	9.17 ± 2.31	4.1 – 10.4	6.93 ± 2.87	5	5
13.	BOD (mg/l)	2.1 ± 0.46	1.60 ± 0.80	1.0 – 2.0	1.85 ± 0.63	6	-
14.	Nitrate (mg/l)	0.60 ± 0.20	0.37 ± 0.15	0.2 – 0.8	0.48 ± 0.20	50	40
15.	Phosphate (mg/l)	0.70 ± 0.03	0.68 ± 0.01	0.68 – 0.72	0.69 ± 0.02	0.50	-
16.	Sulphate (mg/l)	652 ± 204	609 ± 233	348 – 810	630 ± 197	200	-

Table 3 shows the mean and standard deviation of the heavy metals, Pb, Cd, Fe and Zn in the surface water of the river of which Zn was not detected throughout the period of study.

Table 3: Mean Levels of heavy metals in the surface water

Description	Pb (mg/l)	Cd (mg/l)	Fe (mg/l)	Zn (mg/l)
Station 1	0.70 ± 0.51	0.20 ± 0.10	2.10 ± 0.10	ND
Station 2	0.34 ± 0.19	0.21 ± 0.02	1.61 ± 1.69	ND
Range	0.00 – 1.088	0.00 – 0.245	0.076 – 4.407	-
Standard	0.01 - (WHO) 0.10 (NESREA)	0.0903 (WHO, 2014)	0.3	

ND = Not Detected

Table 4 below shows the mean, standard deviation and range of the heavy metals in the sediment of the two stations.

Table 4: Mean Level of heavy metal in the sediment

Description	Pb (mg/l)	Cd (mg/l)	Fe (mg/l)	Zn (mg/l)
Station 1	0.38 ± 0.50	0.10 ± 0.00	18.02 ± 11.34	0.13 ± 0.12
Station 2	0.15 ± 0.18	0.03 ± 0.04	28.68 ± 5.10	0.34 ± 0.15
Range	0.014 – 1.088	0.00 – 0.108	3.806 – 33.62	0.032 – 0.40
DPR/FEPA	2 – 20	0.03 – 0.30	20	50 – 300

Temperature
Most aquatic organism can survive within a temperature of <30°C. The mean values for both stations were 28.4±0.74 and 28.2±0.80°C for station 1 and 2 respectively. This indicates that the temperature of the water is within the permissible limit given by WHO and NESREA. The temperature of both stations were not significantly different (p>0.05). Although the temperature of water is not always stable, there was little variation between stations when compared with the finding obtained in a study conducted by [17]. In Port Harcourt having a temperature range from 26.3 to 26.8°C among the study sites.

pH
Most aquatic organism can survive in a pot range of 4.0 to 10.0 but most organisms prefer a range of 6.5 to 8.0. Increase in pH is associated with increasing use of alkaline detergent in residential areas and alkaline materials from industrial effluents. There was no significant difference between the pH across the stations (p>0.05). The mean pH (6.99±0.19) was within the local NESREA (6.2-9.2) and international (WHO) standard limits (6.5-8.5) reported lower pH value of 6.77 in Island/Diobu Creek [17].

Electrical Conductivity
Conductivity measures how well an electrical current can pass through water due to the presence of dissolved minerals and salts (mineralization of water) such as Cl^-, SO_4^{2-}, Mg^{2+}, K^+, and Na^+ ions [18]. The mean electrical conductivity for station 1 was 16,753 ± 4,295µS/cm and 11,490 ± 2,566µS/cm for station 2. The water has very high electrical conductivity compared to what is obtainable in freshwater. There was no significant difference among the conductivity across the stations (p>0.05). The range of conductivity was 9,890µs/cm to 21,400µs/cm and mean value of 14,122 ± 4,280 (µs/cm) accounting for its high mineralization which is far above the limit of 1000µs/cm (WHO) and 500 µs/cm (NESREA). The high conductivity can be attributed to dissolved solids and ions whose excess might have being caused by waste disposal, runoff and effluent discharge.

Salinity
Salinity is a measure of all the salts dissolved in water. It ranges from 6.98ppt to 12.3ppt for station 1 and 4.86ppt to 7.28ppt for station 2. The mean concentration of salt in the river was found to be 7.77 ± 2.56 ppt which was high and above the limit of 0.04ppt (WHO) and is responsible for its mineralization. This shows that it is not good for drinking, domestic purposes and recreational activity.

TDS
Total dissolved solid is a measure of the content of inorganic and organic substances present in water. The mean values for station 1 and 2 are 15,333 ± 4,050 mg/l and 10,253 ± 2,291 mg/l respectively which show that TDS is high compared to WHO limit and also account for it salt water nature.

Turbidity
Turbidity measures the visibility of the water. It shows how clear the water body is and it is a function of the total suspended solids as well as the dissolved solids in the water sample. The obtained turbidity values for station 1 ranged from 2.55 – 4.29 NTU while that of station 2 ranged from 2.58 – 3.18 NTU. They both have a mean value of 3.2 ± 0.94 NTU and 2.98 ± 0.34 NTU which were below the limit of 5.0 NTU set by WHO and NESREA showing that the water is clear [19].

Total Alkalinity (TA)
Total alkalinity is the capacity of an aqueous solution to neutralize an acid and is mainly due to the presence of bicarbonate, carbonate and hydroxide compounds of calcium, sodium and potassium [18]. The mean value for station 1 and 2 were 45.3 ± 6.43 and 36.7 ± 6.11mg/l. The high total alkalinity content could be the reason why the variation pH was not much because the buttering capacity of the water is high from the values obtained for its total alkalinity. They were all below the recommended limit of 80 – 150mg/l given by WHO.

Total Hardness (TH)
The total hardness ranged from 5760mg/l to 6,912mg/l for station 1 and 2496mg/l to 4608mg/l for station 2. From the mean total hardiness, it shows that the water is very hard and not good for washing because it wastes soap. Station 1 was found to be high in TH concentration

than station 2. The values obtained were far above the recommended standard by WHO. Based on the total hardness values, Mgbuodohia river water generally falls under very hard category of hardness.

Calcium and Magnesium

Calcium and magnesium are responsible for the total hardness of water. The concentration of calcium across the two stations ranges from 307mg/l-768mg/l with mean value of 499±166 (mg/l). As the amount of calcium increases the hardness also increase and vice versa. The magnesium ion values ranged from 422-1218mg/l with a mean value of 921± 67mg/l across the two stations. Both calcium and magnesium were above the limit 75mg/l and 30mg/l given by WHO. This is similar to the study conducted by Arimieri et al. on Island Creek of which the magnesium and calcium levels were above the WHO limits [17].

Chloride

Chloride is widely distributed in nature in the form of sodium chloride (NaCl), potassium chloride (KCl) and calcium chloride ($CaCl_2$). The various sources that contribute to chloride in water are leaching from rocks. From computation, the water was found to have a mean chloride value of 12623 ± 5581mg/l showing that the water is high in chloride and above the recommended standard of 250mg/l by NESREA and WHO.

Dissolved Oxygen (DO)

The concentration of dissolved oxygen depends on physical, chemical and biological activities of the body of water. The river was found to have an average value of 6.93 ± 2.87mg/l similar to 7.3mg/l obtained by [15].an indication of little or no pollution. There was no significant difference between the DO of station 1 and station 2 (p>0.05).

Biochemical Oxygen Demand (BOD)

BOD is the total amount at oxygen required by aerobic microorganisms for complete degradation of organic wastes present in a water body. High value of BOD is an indicator of high level of organic pollution [20]. Values above 6.0mg/l shows that the water has attendant organic load which is undesirable. Station 1 and 2 had mean values of 2.1 ± 0.46mg/l and 1.60±0.80mg/l respectively. The result obtained was similar to that of Arimieri of which BOD value was 2.4mg/l [17].

Nutrients

Nitrates, phosphate and sulphate are referred to as nutrients. Their presence lead to algae bloom in water bodies. The mean concentration of nitrate in station 1 was 0.60 ± 0.20 mg/l and 0.37 ± 0.15 mg/l in station 2 respectively. The result shows that nitrate is low compared to WHO standard. The mean concentration of phosphate in station 1 was 0.70 ± 0.03mg/l and that of station 2 was 0.68 ± 0.01mg/l, both above the recommended standard of 0.50 mg/l by WHO. The sulphate concentration of the water samples ranged from 348 to 810 mg/l. This was above 200 mg/l recommended by WHO.

WQI Analysis

Water quality index (WQI) is the most effective way to communicate the quality of a body of water [15]. Water quality index of 0 (zero) means complete absence of pollutants. When WQI < 100, it indicates that the water is under consideration and fit for human use and WQI > 100 shows unsuitability for human use [21]. Table 5 shows the water quality of the river. The result obtained for the WQI of the river is 425 suggesting that it is not fit for human consumption (Table 6).

Table 5: Water Quality Index (WQI) Value of the Surface Water

Parameter	V_i	V_o	S_i	Q_i	W_i	$1/S_i$	Q_iW_i
DO	6.93	14.6	5	-1059	0.0706	0.2	-74.97
BOD	1.87	0	6	187	0.059	0.1667	11.03
pH	6.99	7	8.5	-83.35	0.0416	0.1176	-3.471
Turbidity	3.09	0	5	309	0.0708	0.2	21.88
TDS	12,793	0	1200	1279300	0.0003	0.0008	377.4
Temperature	28.3	0	30	2830	0.0118	0.0333	33.39
Alkalinity	39	0	150	3900	0.003	0.0067	9.204
Phosphate	0.69	0	0.5	69	0.708	2	48.85
Nitrate	0.48	0	10	48	0.0354	0.1	33.39
Σ					1.000	2.825	425

K=0.354 **WQI**= 425

Table 6: Water Quality Rating as Per Weight Arithmetic Water Quality Index Method

WQI Value	Rating of Water Quality	Grading
0 – 25	Excellent Water Quality	A
26 – 50	Good Water Quality	B
51 – 75	Poor Water Quality	C
76 – 100	Very Poor Water quality	D
Above 100	Unsuitable For Drinking Purpose	E

The Concentration of Heavy Metals in Surface Water

Zn was not detected in the water sample throughout the study. The level of Pb was 0.70±0.51mg/l for station 1 and 0.34±0.19mg/l for station 2. These values were above the WHO standard limit of 0.01 mg/l for drinking water. The high values could be attributed to effluents from oil companies and runoff from the dumpsite.

The mean concentrations of cadmium were 0.20±0.10mg/l and 0.21±0.02mg/l for stations 1 and 2 respectively. These were above the limit of 0.0903mg/l for potable water specified by WHO. This could be attributed to the municipal runoff from the community which may probably contain cadmium compounds. In comparison, the assessment of urban river in developing country showed high mean concentration of cadmium (0.011mg/l) in the winter and 0.088mg/l in the summer which greatly exceeded the drinking water standard value of 0.005mg/l (Drinking Water Standard for Bangladesh). It also exceeded the toxicity reference value (TRV) for fresh water proposed by USEPA. It shows that water from this river is not good drinking or cooking [22].

Iron was the most concentrated heavy metal in the surface water with a mean concentration of 2.10 ± 0.10mg/l at the downstream and 1.61 ± 1.69mg/l at the upstream. The level of Fe in the river was found to be above the USEPA limit of 0.030mg/l. In comparison with the study conducted by Arimieari in the assessment of surface water quality in some selected locations in Port Harcourt, Nigeria, the level of iron was reported to range from 0.176 to 0.866mg/l of which the Island Creek was 0.176mg/l [17]. This means that four years ago the Island Creek was reported to be free of iron pollution, but from this study, it is obvious that the surface water of Mgbuodohia River a segment of the Island River is contaminated with iron because it exceeds the permissible limit of 0.3mg/l (WHO). Iron occurs in minerals as hematite, taconite and pyrite. Elevated iron level in water can cause stains in plumbing, laundry and cooking utensils and can impart objectionable taste and colour to water.

The level of heavy metal under study was found to follow the trend Fe > Pb > Cd.

The mean concentrations of metals in the downstream were relatively high except Cd that was slightly low in the downstream. The high levels may be due to the upstream - downstream movement and deposition of suspended sediments containing heavy metals combined with local pollution in the low reaches [23].

Heavy Metals in the Sediment

The mean levels of Pb for Stations 1 and 2 were 0.38 ± 0.50 mg/kg and 0.15 ± 0.18mg/kg respectively. Although the values were below the limits of 2 – 20mg/l DPR, but toxic at low levels (USEPA). Lead poisoning could lead to deficiency in cognitive function due to destruction of the central nervous system, formation of weak bones as Pb replaces calcium, abdominal pain and discomfort (WHO).

The mean concentrations of cadmium in stations 1 and 2 were 0.10 ± 0.00 mg/kg and 0.03±0.04 mg/kg respectively. The values were below the recommended limit of 0.6mg/kg [24].

The low level in station 2 could be due to remobilization of Cd back to water. In aquatic systems, metals are transported either in solution or on the surface of suspended sediments [24]. Metals had strong affinity for particles. The presence of cadmium in the sediment may be due to direct, discharge to deposition from effluents though not in harmful concentrations.

The mean level of Fe at Station 1 was 18.02 ± 11.34mg/kg while station 2 was 28.68 ± 5.10mg/kg. The high level of iron upstream could be from municipal run-off and residual wastes. The comparatively low concentration at the downstream could be due to mobilization of the metal back to water and uptake by the aquatic flora and probably bioaccumulation in the biota [25]. The level of Fe in the sediment is much higher than other metals under study. This is because Fe occurs naturally in the earth crust and is released through rock weathering [26].

Zinc was present in the sediment at both stations unlike the surface water where it was not detected. The mean concentrations of zinc (Zn) in station 1 and 2 were 0.13 ± 0.12 mg/kg and 0.34 ± 0.15mg/kg respectively. The values were below the limits (50–300mg/kg) set by the Department of Petroleum Resources (DPR).

The concentrations of heavy metals in the sediment were not significantly different from those in water ($p>0.05$) except iron that was significantly greater in sediment than surface water ($p<0.05$). This could be as a result of the high mobility of Pb and Cd as reported [22].

In their study of heavy metal pollution in surface water and sediment, a preliminary assessment of an urban river in a developing country showed that iron level in sediment was higher than that in water. Similar observation was recorded in the assessment of water quality of selected locations in Port Harcourt [17]. This contains the fact that sediment acts as a natural sink for heavy metals and other pollutants in surface water. The presence of heavy metals in the sediment may be attributed to the practice of discharging untreated domestic and industrial waste into the water body, run off from the dump site at station 1 may also lead to increase in the levels of metals in the river sediment.

Conclusion

The levels of sulphate, phosphate and chloride in surface water were above the recommended standard. The mineralization of the river was high due to the dissolved ions that were very much above the permissible limit. All the metals were within the recommended standard in both water and sediment except the concentration of Iron that was high in water and sediment. The WQI, by use of arithmetic weighted method, showed that the overall quality of the river was bad and not suitable for human use mostly domestic activities [27-29].

Recommendations

Further research should be carried out on the river possibly by increasing the number of stations. The bacterial load of the river should be considered by determining the total coliform count, faecal coliform and total heterotrophic bacteria of the river. Other toxic heavy metals like Arsenic, Mercury and Chromium should be evaluated as well. Government environmental authorities should create an avenue for municipal waste collection so that those settling in the area will not continue to use the river as their dumping site and septic tank.

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